NOMATEN Seminar

Raman spectroscopic studies of Polymer Derived Ceramics in the form of protective coatings for SOFCs' interconnects

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April 20th 2021 at 1:00-2:30PM CET (13-14:30 GMT+1)

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Abstract:

Nowadays, with an exponentially increasing amount of people over the world along witha rising demand for the energy, an emphasis is put on the development of the low-emission energy production technologies such as Solid Oxide Fuel Cells (SOFCs). However, despite high electrical efficiency, easiness in manufacturing and low costs of their production, the problem of high-temperature corrosion of SOFCs' interconnects casts a shadow on such a promising idea [1].

Among abundant solutions, the application of protective coatings on the ferritic steels seems to be the most interesting one [1]. Thus, in this work, Polymer Derived Ceramics (PDCs) in the form of SiAlOC glasses' coatings were proposed as a very innovative protection measure. Due to the duality of carbon form (Si-C covalent strong bonds and so called "free carbon phase"), the necessary balance between high thermomechanical stability and electrical conductivity is provided, respectively. Moreover, sol-gel method gives an opportunity to form PDCs in numerous shapes i.e. layers [2].

It is crucial to report that vibrational spectroscopy, including especially Raman spectroscopy is the powerful tool when investigating material's structure, but at the same time very underestimated while determining high-temperature corrosion phenomena and mechanisms of diffusive processes, particularly for the ferritic steels.

The main aim of this study was to present the possibilities of Raman spectroscopy as a method of the evaluation of corrosion rate of Crofer 22APU ferritic steel used for SOFCs' interconnects in two systems: uncoated and coated with layers based on SiAlOC glasses.

The corrosion resistance of the protective layers was investigated using thermogravimetric analysis within isothermal (500 h) and cyclic (500 1h-cycles) conditions at 800°C in the laboratory air. The application of Raman spectroscopy allowed for the determination of:

a) bulk material's (gel and glasses) structure used as reference for coatings – point measurements,

b) structure of coating along with coating/steel interface ($MnCr_2O_4$ spinel) – linear depth profiles,

c) distribution of oxidation products on the surface and across the multi-layered scale - imaging.

The Raman studies supported with additional structural (XRD, FTIR) and microstructural (SEM+EPMA) investigation, revealed the outbreak improvement in the oxidation resistance of the steel due to the application of SiAlOC glasses coatings.

Acknowledgments

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References

[1] Tan KH, Rahman HA, Taib H, *International Journal of Hydrogen Energy* (2019); 44, 30591-30605.

[2] Stabler C, Ionescu E, Graczyk-Zajac M, Gonzalo-Juan I, Riedel R, (2018); *Journal of the American Ceramic Society* 101, 4817-4856.

Speaker's bio:

Maciej Bik graduated from Faculty of Materials Science and Ceramics at AGH University of Science and Technology in Cracow with honors as M.Sc. of Materials Science (specialization: Functional Materials). Currently he is finishing his PhD ("Black glasses as protective coatings for heat-resistant alloys in high-temperature corrosion conditions) under the supervision of Prof. Maciej Sitarz. During his research, M.Sc. Eng. Maciej Bik focuses on the application of Polymer Derived Ceramics (PDCs) from SiOC and SiAlOC systems in the form of protective layers on different types of metallic substrates (i.e. stainless steels

such as Crofer 22APU or Cr, TiAl and FeAl alloys) and the investigation of high-temperature corrosion phenomena using novel combination of spectroscopic studies, such as Fourier Transformed Infrared (FT-IR) spectroscopy and Confocal Raman Imaging. Until now, M.Sc. Eng.

Maciej Bik participates in numerous internships i.e. in Dispersive Solids Group at Technical University of Darmstadt (thermal studies of PDCs under supervision of Prof. Ralf Riedel) and in High Temperature Materials Group (application of coatings based on SiAlOC glasses on different metallic substrates i.e. Cr and TiAl alloys, under the supervision of Prof. Mathias Galetz). During his scientific career, M.Sc. Eng. Maciej Bik received abundant projects (Project leader of Diamond Grant from Ministry of Science and Higher Education in 2017 and ETIUDA from National Science Centre in 2020) as well as participated in others (Contractor i.e. in OPUS projects from National Science Centre).

He is an author or co-author of 11 publications (H-index = 4), as well as speaker at 10 international conferences all over the world. His scientific activities and achievements have been awarded with a Scholarship of Minister of Science and Higher Education for scientific achievements (2016) and young talented scientists (2020), as well as Scholarship “START 2020” of Foundation for Polish Science.